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Canadian Society of Civil Engineers.

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TRANSACTIONS.

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ON A NEW AND CHEAP METHOD OF DRESSING CAR WHEELS, AXLES, ETC., ETC.

By R. ATKINSON, M.CAN.SOC. C. E.

To be read Thursday, 7th January, 1837.

The art of dressing the harder kinds of metal, such as iron, in the cold state has within historic periods depended upon the grindstone, and it is not until comparatively recent years that other means have become known which reduce the length of time required by the expenditure of more power, or, in other words, since hand labour has been replaced by machinery.

The working of iron in the cold state by means of machinery to cut or dress it has largely supplemented the art of working hot iron for more than a century, and has been the only known means except the grindstone for dressing or finishing iron and its various alloys until late years. The greatest departure from the work of the grindstone was probably made by the introduction of the emery wheel, which differs from the grindstone in being revolved very rapidly, and therefore in doing more work in the same time, thereby replacing time by power; but, on the other hand, it is like the grindstone, in that it loses much more of its own substance than it removes from the material operated upon. A further advance was made in the art by the introduction of the blind saw for cross cutting bars of iron or steel, such as rails, etc., in the cold state. In its operation, the most notable feature is, that less of the operating material is displaced than is removed from the material operated upon, even though the latter is the harder substance. This may be looked upon as being, until recently, the latest form of the attempt to substitute power for time in the manipulation of cold iron or steel.

The author will, however, endeavour to give a description of what appears to be a further distinct advance, inasmuch as the effect is not only to remove more metal in a given time, but also to leave the surfaces so dressed in more perfect state than heretofore for the work they are intended to perform. This is accomplished by the Sibbald machine and process which was primarily intended for dressing journals or other forms of finished work. Such a machine has been built and operated in actual commercial form in the presence of some members of this Society, but it has been developed still further in England after more experience and with better source of power, under instructions from its present owners. The first occasion on which the writer had the pleasure of seeing the first crude machine in operation was in May, 1886, at the works of Mr. W. G. Miltimore at Arlington, Vt., when it was used to dress cast iron car wheels. A heavier and

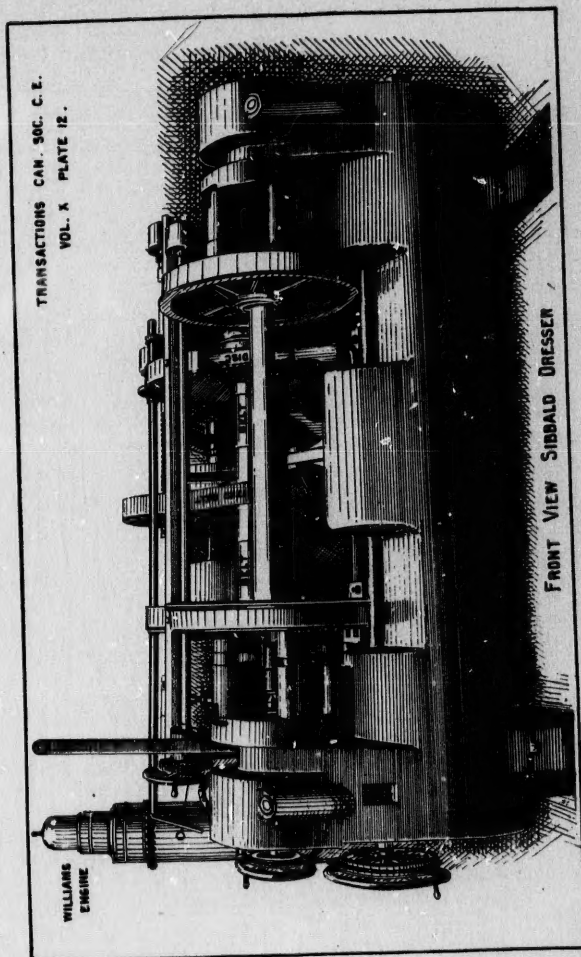
improved machine was afterwards built by Messrs. J. Laurie & Bro. of this city, under the direction of Mr. W. C. Farnam, and operated in a shed at the old Canadian Pacific Railway works at Hochelaga. In this case the source of power was not at all satisfactory, for when it is considered that from 100 H.P. to 200 H.P. are required, there is obvious necessity for both reliable and economical motive power.

A description of the machine may be given as follows. A ring about 33 inches diameter of mild steel (of about .65 per cent. carbon) is fixed like the tyre of a locomotive driving wheel on a suitable centre, which is mounted on a heavy shaft, and has its periphery turned to produce the proper profile on the wheel to be operated upon, and very carefully balanced. The disc thus formed is driven at a speed of about 3,000 revolutions per minute. The wheel is set in a suitable carrier and is revolved slowly, about two or three revolutions per minute, so that the surface when brought against the operating disc will move in an opposite direction. The wheel and disc are then pressed together with a force sufficient to cause friction enough to consume a great part of the power which is driving the disc, and thus convert the power into heat. The disc cuts or rubs off the metal of the wheel operated upon, and leaves a smooth finished surface, which by the pressure and heat is closed and hardened to a considerable degree and to a depth of 100th of an inch or more depending on the grade of the steel worked upon.

The principal constructive feature in the machine itself is the manner in which the friction on the journals of the disc, which would result from the combined great pressure and high speed, is overcome by a system of forced lubrication, carried out by pumping oil into the bearings at the point of contact, thus causing the shaft to revolve upon a film of oil which flows out at the ends where it is collected by centrifugal force and returned to the pumps.

In the latest form of this machine as operated at the works of Messrs. Easton, Anderson & Goolden, Erith, Kent, it was found that by sending an electrical current through the point of contact of the fusing disc and wheel, so as to heat the wheel at that point, a very great reduction in the power could be made, or much more material removed by the same power in a given time. The following extract from a report made by that firm will explain this fully:

"The reason why the disc cuts metals harder and tougher than itself is apparent when the operation is analyzed. The mechanical equivalent of heat, as demonstrated by Dr. Joule and others, equals about 42 units of heat per horse power per minute, thus giving at the periphery of disc a heating effect directly in proportion to the horse power applied, as all the net power delivered to disc is converted into heat by frictional resistance and disturbance of metal under operation. As the power is consumed and the heat generated where the disturbance of metal under operation takes place, it follows that a greater part of the heat is generated in the metal being removed. The disc being kept cool by conduction and radiation into the atmosphere, or by application of water, its surface is not disturbed, and consequently very little heat is generated within the disc. The high velocity of the disc, viz., 33,000 feet per minute, requires only 1 lb. frictional resistance to the movement of the disc per horse power applied. Thus in the consumption of 100 horse power 100 lbs. frictional resistance to the movement of the disc is given; this distributed over the surface of contact between the metal under operation and disc, which exceeds one square inch at all times, is not sufficient to abrade or injure the surface of the disc. With 100 net horse power, we have a total heating capacity of 4,200 calories or English units of heat per minute, equal to raising the temperature of 4,200 lbs. of water one degree Fahrenheit, and as the specific heat of steel is 0.12, it follows that



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this horse power will raise the temperature of 35,000 lbs. of steel one degree; this equals 14 lbs. heated to 2,500 degrees, the temperature to which steel is heated in removal by this process. The percentage of the total heat equivalent to net power delivered to disc utilized in actual work is indicated in last column in accompanying report of test made at Erith Iron Works, April 6th, 1892."

" ELECTRICAL SUPPLEMENT.

" It is indicated by experiments at Erith Iron Works and elsewhere, that a greater heating efficiency can be got from the electrical current applied at points of contact between heating disc and object being dressed, than from the power frictionally consumed, and that considerable saving can be made by applying a large percentage electrically, sufficient power only being applied to the disc to remove the metal heated by electrical current. The effect of the current is not destructive, owing to the distribution over its whole peripheral surface; and as current is passed through the heated spot in the metal under operation, where the greatest resistance takes place, owing to high temperature and small surface, we consume most of current within the body of the metal being removed, consequently the higher percentage of efficiency. The current applied in very small quantities appears to greatly increase the co-efficient of friction, and thus less friction between surfaces is required to consume the power and generate its equivalent in heat; consequently a gain is made in reduced frictional resistance throughout the journal bearings of machine, in addition to the heating effect of current.

" The gain in mileage life of car wheel tires hardened by this process over those in ordinary condition (as indicated by the greatly reduced wear of tires dressed by this process and the increased durability of chilled iron wheels over those of soft iron) must be great, and if the advantages of this process are fully utilized by re-dressing soon after the hardened surface is worn off, the mileage life of tires will be at least doubled. The cost of dressing when only sufficient metal is removed to reproduce the hardened surface will be considerably less than is shown in the report of tests made April 6th, 1892, at Erith Iron Works.

" In addition to the dressing of railway wheel tires, the process is particularly well suited to the finishing and hardening of journal surfaces in all classes of machinery where journals are subjected to considerable pressure and speed. The journals of railway axles are rendered very much more durable, and will give proportionately less trouble when dressed and hardened by this process. It is only necessary in dressing journals to remove a small amount of stock, $\frac{1}{32}$ being quite sufficient to harden surface, and this does not distort or spring the journal, as is the case where journals or spindles are case hardened or tempered throughout, although the surface produced by this process is much harder, more dense, and in every way more perfect than is possible to get from any other method of hardening. Milling rolls of suitable steel (which may be softly annealed if desired) may be dressed, and a surface produced much harder and more durable than that of chilled iron; rolls of chilled iron can also be most economically dressed by this process, when electrical current is used to increase friction and heat metal being removed. The expense of hardening journals by this process is slight, as very little metal is removed. The report of car wheel dresser trials, with and without the electrical current, is entirely based upon observations and data made by two competent experts, acting quite independently of each other in taking observations and indicator cards alternately throughout the trial. The reports from each expert were made independently, the result showing only a very slight percentage of difference between the two. The conclusions in

foot note of report are entirely based upon actual results attained during these trials, and as a trial machine is very imperfect in many essential points, it is expected that a much higher percentage of efficiency can be attained with the proposed new machine, although this is not assumed or indicated in the report."

The report alluded to in the above extract was made by Mr. Dickinson, C.E., of Messrs. Easton & Anderson, and reads as per attached statement marked "B".

It may therefore be assumed, allowing for the difference in cost of labour, that 15 cents per wheel would be ample allowance even for removing the large amount of 16 pounds per wheel. This would give 60 wheels in a day of 10 hours. The output of an ordinary wheel lathe is from $1\frac{1}{2}$ to 4 pairs per day, depending upon the work necessary and the build of the machine. The number of cast iron wheels which may be dressed per day is so variable that it is almost impossible to form an estimate of the average, depending as it does upon the condition of the wheel.

The great importance to railways of some means of dressing car wheels, both cast and wrought iron, at less expense than is now incurred, has been also shown in the following report by F. R. F. Brown, Esq., M.Inst. C.E., W. Laurie, Esq., M. Can. Soc. C. E., and the writer, marked "A."

Questions have often been asked as to whether any damage could result to the cast iron wheel, but the writer cannot say that there is any probability of damage occurring. These questions may be formulated as follows:—

(1) Does the pressure of the dressing disc against the wheel while being dressed have any detrimental effect upon the body of the wheel?

(2) Does the heat generated by dressing cause disintegration of the surface metal when cold, or do the chilled portions of cast iron wheels crack, shell out or separate from the grey portion, as a result of the operation of this machine?

(3) In the case of steel tires, will the film of metal which has apparently been fused separate from the wheel, i.e., "peel off"?

The writer had occasion to inspect the pair of second hand cast iron wheels alluded to on page — which had been dressed to remove flat spots about 2 inches diameter, and after being replaced in service had been run 14,000 miles until worn through the clear chill, and began to show the mottled metal beneath, and were then still in good condition as to shape and surface.

From this inspection the writer would say as follows, viz.:—

(1) Since the pressure of the disc is less than the load when in service, and all the shocks of service are avoided, it is manifestly impossible for the pressure during the operation of dressing to be in any way detrimental to the body of the wheel.

(2) The wheels in service showed no defect or disintegration of the chill whatever, and are in no way to be distinguished from other wheels (not dressed) in any respect except superior form.

(3) The writer has not seen any steel tired wheels in service which had been dressed on this machine, but he is strongly of the opinion that not the slightest cracking or peeling off can possibly take place—in fact, he views it as utterly impossible, since he has had pieces broken out of steel tires repeatedly without any indication of such defect.

The economic value of this machine lies in substituting power for time, and the saving depends of course upon the cost of power. What this cost should be has been the subject of much discussion, but in the writer's opinion a well-designed steam plant in favourable locality should develop one horse power for a cost of one cent per hour.

APPENDIX A.

WHEEL DRESSING MACHINE. ITS ACTION AND ADVANTAGES.

INCREASED DURABILITY OF TIRE.

When an ordinary steel tired wheel is turned in a lathe, the effect of the tool is to break or open up the surface to a greater or less depth beyond the point of the cutting tool, the depth so disintegrated being very variable and depending upon the hardness of tire, shape and condition of cutting tool, and so on. The obvious result is that the surface of a turned tire is not solid material, but is more or less spongy, and must be hammered or rolled down to a smooth face when put into service by the effect of the load carried, consequently the actual useful diameter of a turned tire is appreciably less than the apparent diameter. On the other hand, the surface of a tire submitted to the process of dressing by fusing or grinding is as perfectly smooth as if it had rolled on the track for months, and its hardness is not approached by anything so nearly as by the process of case hardening, which is so well known as producing the most perfect surface to withstand friction.

The effect of this is to cause a corresponding increase in the mileage of the wheel before even the slightest signs of wear are to be detected, one pair of the wheels having shown a record of 10,000 miles without perceptible wear, so far as any alteration of form of tread shewed.

The process of turning exaggerates the effect of any difference in hardness between two tires of wheels on the same axle, so that the softer tire rapidly becomes the smaller wheel, and causes tendency to "sharp-flange." On the other hand, the process of dressing by fusing puts an approximately equally hard and equally durable surface on both tires. When in the course of time the hard surface is worn through and the softer tire begins to get smaller and shews wear on the flange, the two wheels can be dressed and the action stopped. The dressing by fusing in this way makes tires of unequal hardness practically as good as those of equal hardness. When a steel tire is turned, its apparent diameter, as above shewn, is greater than its actual useful diameter by an amount varying with the amount of porosity or sponginess produced in turning, and which may be set down at $\frac{1}{32}$ " on the thickness of the tire. Some kinds of tool finish may produce less depth of porosity, but they require a greater thickness of steel to be turned off to produce their results. It is necessary also to cut below the lowest spot in order to make the tool stand. The depth necessary for this depends much on the hardness of the material, but in any case it may be taken at $\frac{1}{32}$ " below the lowest spot. When the wheel has made say 500 miles, and regained the hard surface with which it came into the shop, it will have lost another $\frac{1}{32}$ " or in all $\frac{1}{16}$ " due to the turning. It may be taken that a tire requires on the average not less than one turning for every quarter of an inch of its useful or wearable thickness, of which the above loss of $\frac{1}{16}$ " forms a part, and it therefore loses 25 p. c. of its useful thickness in turnings only.

The operation of grinding or dressing by fusing avoids all this loss, since the fusing disc can be done so perfectly as to either leave a "witness" at the lowest spot of a skidded wheel, or to just take it out sufficiently to harden the surface at that point and make it to conform to the other portions of the wheel.

If we consider the effect of turning on the mileage, we may take as a basis that a 40" tire would be reduced $\frac{1}{4}$ " per 40,000 miles run, which is an ordinary figure; and that if the tire is $2\frac{1}{2}$ " thick when new, and rejected at $1\frac{1}{4}$ " thick, it would receive five turnings, or its life would be 200,000 miles. If these five operations were done by fusing there would be a saving of 25 per cent. of steel, or an increased life of 33 per cent., which would make the total mileage 266,000. The

lowest estimate at which the effect of hardening the tread at these five furlongs and hardenings could be placed would be to double the mileage, which would therefore be 532,000 miles. And as the original basis of 40,000 miles per $\frac{1}{4}$ " wear includes all tires taken out for sharp flanging, which would be also largely obviated, a low estimate of the life of 40" steel tire is that it would be raised to upwards of 600,000 miles.

The shape of the tire after being turned depends to some extent upon the care which the turner bestows upon it, and as usual the human factor succeeds in frequently introducing errors of greater or less extent which are not always found out till too late. In the fusing process the shape of the fusing disc itself determines the shape of the tread of the wheel, and gives no opportunity for errors. The machine also admits of being adjusted to give absolutely equal diameters in pairs of wheels on the same axle, and there can therefore be no loss from sharp flanges caused by unequal diameters of wheels. Any inclination to sharp-flange would at once shew the necessity of further examination, and would materially assist the supervision of the work.

PREVENTION OF SHARP FLANGES AND CONSEQUENT DANGER

So long as a pair of wheels can be kept from running to one side, and sharp-flanging be prevented, they can cause no derailment; but if from any defect, either in the wheels themselves or in the truck or frame in which they run, one wheel of a pair commences to sharp flange, there is immediate danger of derailment, and, what is much worse, danger from the breaking of an axle, an occurrence which unfortunately is only too common.

This is due to the effect of excessive side pressure producing a bending moment in the axle, an effect which with due care may be very largely diminished, though not of course entirely overcome. When sharp-flanging occurs to any extent, it is an imperative reason for wheels being taken out and turned afresh. From neglect of this an enormous loss in mileage arises, wheels having frequently to be turned $\frac{3}{8}$ " smaller in radius or thickness of tire merely to make a new but still defective flange. Wheels thus taken out and turned because of sharp flanges would probably have made a further mileage of 20,000 miles before requiring to be turned on account of wear of the tread as distinct from that of the flange.

This loss due to sharp flanging cannot be stopped by turning, because the cost for wheel turning plant and the loss of thickness in tires would be too great. On the other hand, sharp flanging would be almost unknown in wheels dressed by the fusing process. When it did occur it would be from a defective truck or other cause outside the wheels, and any damage sustained from it by the wheels could be remedied at the cost of a few cents and almost no loss of steel while they are out of the truck to allow of its being repaired.

REDUCTION OF WEAR AND TEAR OF CARS AND TRUCKS.

The great wear and tear on trucks, boxes, brasses, hangers, etc., due to wheels not running freely on the track, is something not generally realized. At least 10 per cent. of the bearings put in axle boxes are spoiled by end wear, which is principally due to wheels running to one side. Nothing will put a truck "out of square" more quickly than a pair of wheels forming a sharp flange, and then it follows that the other pair in the same truck will become sharp flanged too. And when one truck or a car is running badly, the effect of the pull of the other cars is to cause it to rebound from the side of track and to increase its side motion, and thus they react upon and damage each other.

The wear and tear on rails sideways must be at least equal to the wear on the flange of the tire, the rail being the softer metal, and thus the rail deteriorates rapidly. A wheel with a sharp flange is also very

destructive to frogs and switches, and the other wheel of the pair is equally severe upon guard rails, while in turn tremendous shocks are given to the axle.

DECREASED COST OF HAULAGE.

It follows also that the cost of haulage is greatly increased by the friction thus induced. The difference in pull between a free running train in good shape and a hard pulling one in bad condition is evident, and very easily felt by those in charge. It may be fairly estimated that the increase in cost of fuel from such causes is not less and is often more than 10 per cent., and that the cost of repairs is increased in like proportion.

INCREASED COMFORT TO PASSENGERS.

The effect of wheels in bad condition is very irritating to some classes of passengers, and is more or less trying to all, and the opposite is quickly noted by them. With good wheels, windows, sashes and doors do not need to be made nearly tight to prevent rattling, and can be operated with comfort. The coaches lose a great portion of the unpleasant side swing with its consequent wear and tear, and faster time can be made. This is a point of minor importance, but not to be disregarded.

COST OF DRESSING AS COMPARED WITH TURNING.

The operation of the machine at Hochelaga has shown that with proper arrangements for power and handling, only two men will be required to work it. One man—the machine man—will operate the machine exactly as a lathe is operated,—that is, he will put in and take out wheels by the aid of a crane, and do the grinding. The other, the engineer, will stand by the engine, and assist in operating the crane when required.

The output of wheels would vary with the condition of the tread. From six pairs would be done in a day if the flanges are bad, and there is much, say $\frac{3}{16}$ " to be taken off, to probably 20 pairs would be turned out if the full benefit of not allowing the wheels to get into bad shape is thoroughly appreciated.

A good wheel lathe, such as commonly used in railway shops, will turn down an average of $1\frac{1}{2}$ pair of steel tired wheels per day of 10 hours, if not shewing more than $\frac{3}{16}$ " wear on the total diameter, that is not requiring a cut of over $\frac{3}{16}$ " to true them. The cost for wages, power, interest and other working expenses is about \$2.05 per day, or about \$1.64 per pair, two wheels being turned at once.

In dressing by fusing, Mr. Walter H. Laurie, M.E., calculates the cost of operating a wheel grinding machine at \$12.00 per day of 10 hours, covering cost of power, wages of three men, interest and other working expenses. Such a machine would have a capacity, as before mentioned, of not less than six pairs of steel tired wheels in the worst condition that could be found in service, and 20 pairs slightly worn, or say 10 pairs of wheels per day of average bad wear. The maximum power required would not be over 120 H. P., and the average during the day not over 80 H. P. The cost per pair of 10 pairs would therefore be \$1.20, and if 20 pairs, or, in other words, if the full benefit of early dressing by fusing were secured, it would be 60c per pair. The saving by dressing over turning is therefore about 27 p.c. on average wheels, and at least 50 p.c. on those requiring less work.

CAST IRON WHEELS.

The dressing of chilled cast iron wheels is also successfully and economically done by the fusing process, the power required being much less than for steel tired wheels. The time required is of course as variable as for steel tires, but much shorter in all cases. The dressing of new wheels not on axles could be done almost as fast as they could be put in the machine, if no more were done than is done by the emery

grinding processes in use; that is, to just clean the face of the tread for a width of about 3" not more than five minutes actual grinding time per pair would be required for two wheels mounted on a double self-centering chuck. This grinding of wheels separately, however, does not obviate the trouble of "mating" them when required for use, nor does it ensure that the wheel shall be true with the axle when put on. The greatest benefit of dressing can only be derived when wheels can be put on their own axles and turned out in first class condition for service. All the arguments in favour of dressing wheels before the defects which arise in service, such as sharp flanges, skidded spots, snelling out, etc., can do any serious damage, apply to the care of cast iron wheels quite as forcibly as to steel tired wheels. As an instance, it has been found that a pair of well worn wheels rejected for flat spots actually made 14,000 miles after grinding, and were still in fair order.

SUMMARY.

The advantages to be gained by the use of the wheel dressing machine are therefore briefly as follows:

1. Steel tires would be increased about 33 per cent.
2. Increased safety to passengers and rolling stock by prevention of bad flanges.
3. Reduced wear and tear on rolling stock and on rails by keeping of wheels in perfect condition.
4. Locomotive expenses will be reduced by the easier haul of good wheels.
5. Increased comfort to passengers.
6. The cost of dressing steel tires is 27 to 50 per cent. less than turning them.
7. The benefits in dressing cast iron wheels are nearly as great as in steel tired ones.

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WALTER H. LAURIE, *M.E., M.Can.Soc.C.E.*

APPENDIX B.

THE FRICTIONAL AND ELECTRICAL PROCESS FOR SHAPING, HARDENING AND FINISHING METALLIC SURFACES, AS APPLIED IN THE SIBBALD RAILWAY WHEEL DRESSING MACHINE.

In this process a revolving steel disc designed to stand high centrifugal strains is given a peripheral velocity of say 33,000 feet per minute, against which the carriage wheel or other object to be dressed is slowly revolved, enough pressure being applied to cause frictional resistance sufficient to consume power transmitted to the disc, and convert it into heat. The disc cuts or rubs off the heated metal, leaving a smooth hard surface. The hardening effect depends upon the percentage of carbon in metal being worked, and the manner of handling during operation, varying with these conditions from $\frac{1}{100}$ " to $\frac{1}{16}$ " in depth.

It has long been known that a rapidly revolving disc of soft iron would heat and cut its way through iron and steel without injury to itself; little practical use was made of this principle, however, although in use to some extent, for cutting railway rails, tubing, and merchant bars, and other special purposes.

The reason why the disc cuts metal harder and tougher than itself is apparent when the operation is analysed. The mechanical equivalent of heat as demonstrated by Dr. Joule and others equals about 42

units of heat per horse power per minute, thus giving at the periphery of disc a heating effect directly in proportion to the horse power applied, as all the net power delivered to disc is converted into heat by frictional resistance and disturbance of metal under operation. As the power is consumed and the heat generated where the disturbance of metal under operation takes place, it follows that a greater part of the heat is generated in the metal being removed. The disc being kept cool by conduction and radiation into the atmosphere, or by application of water, its surface is not disturbed, and consequently very little heat is generated within the disc.

The high velocity of the disc, viz., 33,000 feet per minute, requires only 1 lb. frictional resistance to the movement of the disc per horse power applied. Thus in the consumption of 100 horse power, 100 lbs. frictional resistance to the movement of the disc is given. This distributed over the surface of contact between the metal under operation and disc, which exceeds one square inch at all times, is not sufficient to abrade or injure the surface of the disc. With 100 net horse power we have a total heating capacity of 4,200 calories or English units of heat per minute, equal to raising the temperature of 4,200 lbs. of water one degree Fahrenheit, and as the specific heat of steel is 0.12, it follows that this horse power will raise the temperature of 35,000 lbs. of steel one degree; this equals 14 lbs. heated to 2,500 degrees, the temperature to which steel is heated in removal by this process.

The percentage of the total heat, equivalent to net power delivered to disc, utilized in actual work, is indicated in last column in accompanying report of test made at Erith Iron Works, April 6th, 1892.

ELECTRICAL SUPPLEMENT.

It is indicated by experiments at Erith Iron Works and elsewhere, that a greater heating efficiency can be got from the electrical current applied at points of contact between heating disc and object being dressed, than from the power frictionally consumed, and that considerable saving can be made by applying a large percentage of the power electrically, sufficient power only being applied to the disc to remove the metal heated by the electrical current. The effect of the current upon disc is not destructive owing to the distribution over its whole peripheral surface, and as current is passed through the heated spot in the metal under operation, where the greatest resistance takes place owing to high temperature and small surface, we consume most of the current within the body of the metal being removed, consequently the higher percentage of efficiency. The current applied in very small quantities appears to greatly increase the co-efficient of friction, and thus less pressure between surfaces is required to consume the power and generate its equivalent in heat; consequently a gain is made in reduced frictional resistance throughout the journal bearings of machine, in addition to the heating effect of current.

The gain in mileage life of car wheel tires hardened by this process over those in ordinary condition (as indicated by the greatly reduced wear of tires dressed by this process and the increased durability of chilled iron wheels over those of soft iron) must be great, and if the advantages of this process are fully utilized by redressing soon after the hardened surface is worn off, the mileage life of tires will be at least doubled. The cost of dressing when only sufficient metal is removed to reproduce the hardened surface will be considerably less than is shown in the report of tests made April 6th, 1892, at Erith Iron Works.

In addition to the dressing of railway wheel tires, the process is peculiarly well suited to the finishing and hardening of journal surfaces in all classes of machinery where journals are subjected to considerable pressure and speed. The journals of railway axles are rendered

very much more durable, and will give proportionately less trouble when dressed and hardened by this process.

It is only necessary in dressing journals to remove a small amount of stock, $\frac{1}{32}$ " being quite sufficient to harden surface, and this does not distort or spring the journal, as is the case where journals or spindles are case hardened or tempered throughout, although the surface produced by this process is much harder, more dense, and in every way more perfect than is possible to get from any other method of hardening. Milling rolls of suitable steel (which may be softly annealed if desired) may be dressed, and a surface produced much harder and more durable than that of chilled iron; rolls of chilled iron can also be most economically dressed by this process, when electrical current is used to increase friction, and heat metal being removed. The expense of hardening journals by this process is slight, as very little metal is removed.

The report of car wheel dresser trials, with and without the electrical current, is entirely based upon observations and data made by two competent experts, acting quite independently of each other in taking observations, and indicator cards alternately throughout the trial. The reports from each expert were made independently, the result showing only a very slight percentage of difference between the two. The conclusions in foot note of report are entirely based upon actual results attained during these trials; and as a trial machine is very imperfect in many essential points, it is expected that a much higher percentage of efficiency can be attained with the proposed new machine, although this is not assumed or indicated in the report.

RESULTS OF CAR WHEEL DRESSER TRIALS WITH AND WITHOUT THE ELECTRICAL CURRENT AT ERITH IRON WORKS, ERITH, KENT, 6TH APRIL, 1892.

Condition of Trial.	I. H. P.		Reduction in Net I.H.P. over mean of No. 3 & 4, by using Electrical Current.	Steel removed per 100 I.H.P. per minute.		Efficiency of Machine. See Note.	Remarks.
	Total.	Net including 15 per cent. for Current.		cubic ins.	lbs.		
1 Engine only..	27.56			Nil	Nil		3168 revs. per min.
2 Engine driving discs	67.36			Nil	Nil		running light.
3 With current.	104.80	39.5	24 p.ct.	10.92	3	21.4 p.c	{ cut $\frac{1}{8}$ " deep traverse 3" per min.
4 Ditto	110.66	45.35	18 p.ct.	9.35	2.61	18.6 p.c	{ diameter of wheel, 36".
5 Without current	119.57	52.21		8.11	2.27	16.2 p.c	{ same feed as in 3 & 4
6 Ditto						3132 " " "	

NOTE.—The efficiency of the machine indicates the percentage of work equivalent to the heat generated at disc to the net horse power delivered to the disc.

With proposed new machine and engine indicating 166 H.P. = say 100 I.H.P. net, 6 wheels per hour could be dressed, removing 16 lbs from each. Allowing 40 per cent. of total time for handling wheels, etc., the mean I.H.P. with machine at constant work being 125, and the estimated cost per wheel, including 1½ lbs. coal per I.H.P. per hour, fireman 25s, machine attendant 35s per week each, and interest and depreciation on plant of £90 per annum, being 5½d per wheel.